DISCOVERY

Improvement of sandy soil properties and wheat (*Triticum aestivum L*) yield using application of chicken manure and canal sediment amendments in high terrace soils of Northern State - Sudan

Ali Abdalla Mohamed, Imran Ali Ahmed, Ammar Wedaa Hammad, Habiballa Abdelhafiz Mohamed

To Cite:
Mohamed AA, Ahmed IA, Hammad AW, Mohamed HA. Improvement of sandy soil properties and wheat (*Triticum aestivum L*) yield using application of chicken manure and canal sediment amendments in high terrace soils of Northern State – Sudan. *Discovery* 2023; 59: e30d1034

Author Affiliation:
National Institute of Desert Studies, University of Gezira, Wad Medani, Sudan

Peer-Review History
Received: 02 February 2023
Reviewed & Revised: 04/February/2023 to 24/February/2023
Accepted: 26 February 2023
Published: March 2023

Peer-Review Model
External peer-review was done through double-blind method.

Discovery
pISSN 2278–5469; eISSN 2278–5450

ABSTRACT

Most soils under arid conditions have extremely low quality due to poor physical conditions, low organic matter and water retention capacity, soil fertility and consequently both low water and fertilizer use efficiencies. This present study was planned to investigate the effects of canal sediment (CS) and chicken manure (CM) on some physical properties of a desert soil and performance of wheat (*Triticum aestivum* L) yield and its components. The experiment was conducted at National Institute of Desert Studies Research Farm for two consecutive winter seasons of (2017/2018) and (2018/19) in a sandy soil of North Sudan. The experiment design was split plot randomized complete block with three replications. The main plot was assigned to canal sediment with three levels (0, 20, 40-ton ha^{-1}) and sub plot were assigned to chicken manure with three rates (0, 2, 4-ton ha^{-1}). The results showed that the effects of both canal sediment and chicken manure were effective in improving the soil bulk density, soil moisture content under investigation and consequently increased wheat yield and its components. Also, the results indicated that the canal sediment and chicken manure reduced soil bulk density increased the soil moisture percentage and wheat yield. The implementation of 40 ton per hectare of canal sediment and 4 ton per hectare of chicken manure was gave highest mean value of wheat yield 9930 Kg ha^{-1} and its components, high moisture content 17.6% and low bulk density 1.43 $gmcm^{-3}$ compere to control. In general trend Canal sediment (CS) and Chicken manure (CM) had significant effect p (≤. 05) in reducing soil bulk density, increasing soil moisture content and highly significant effect p (≤. 01) in increasing wheat yield and yield components.

Keywords: Sandy soil, Canal sediment, Chicken manure.

DISCOVERY SCIENTIFIC SOCIETY

1. INTRODUCTION

Wheat (*Triticuma estivum* L.) is mainly grown in the Sudan under irrigation, during winter months; its cultivation has recently expanded into latitudes lower than 15°N (Ageeb et al., 1996; Almeu and Hazem, 2011). Application of manure in desert plain soil in the Northern Sudan significantly improved the soil chemical properties and minor increased in organic carbon, nitrogen; available phosphorus and potassium were observed Ahmed, (2010). The soil pH was not affected by the source of organic manure, the poultry manure application on sandy loamy soil in Southwestern Nigeria improved soil chemical properties. It increased soil organic matter, total N, available P, exchangeable Mg, Ca, K and nutrient uptake and lowered exchange acidity (Adeleye et al., 2010).

Chicken manure and sewage sludge application on the poor physical and chemical properties of sand dune soil in Elrawakeeb Dry Land Station, Khartoum State, Sudan resulted in very highly significantly increased soil organic carbon, available P, total nitrogen and mineral nitrogen and decreased soil pH (Elhadi et al., 2016; Mubarak et al., 2015). New Hamdab Scheme (Northern State of Sudan) faces problems of mud accumulation in all irrigation canals. Enormous amounts of sediments are being removed during cleaning of these canals. Disposal of this sediment is a real problem. Sediments accumulated in irrigated canals contain high quantities of clay and might be a useful as a soil conditioner (Mubarak et al., 2014).

Ahmed, (2010) stated that application of manure in desert plain soil in the Northern Sudan significantly improved the soil chemical properties and minor increased in organic carbon, nitrogen; available phosphorus and potassium were observed. The soil pH was not affected by the source of organic manure. The poultry manure application on sandy loamy soil in Southwestern Nigeria improved soil chemical properties. It increased soil organic matter, total N, available P, exchangeable Mg, Ca, K and nutrient uptake and lowered exchange acidity (Adeleye et al., 2010). Chicken manure and sewage sludge application on the poor physical and chemical properties of sand dune soil in Elmoakabrab Dry Land Station, Khartoum State, Sudan resulted in very highly significantly increased soil organic carbon, available P, total nitrogen and mineral nitrogen and decreased soil pH (Elhadi et al., 2016).

2. MATERIALS AND METHODS

Field experiments were carried out during two consecutive winter seasons (2017/18 and 2018/19) at the National Institute of Desert Studies Research Farm, New Hamdab Scheme, Northern State of Sudan (latitude 17°55' N and longitude 31°10' E). The climatic zone of the area is described as desert, which is characterized by high temperature in summer, low temperature in winter and low rainfall (Habiballa and Ali, 2010). The soil of the study area belongs to El Multaga soil series which classified as Vertic Haplocambids, fine loamy, mixed, supper active, hyperthermic. The soil structure is moderate sub angular blocky. It is non-saline and non-sodic (see Table 1 below) (LWRC, 1999). Generally, the soil chemical fertility is low and mostly these soils deficient in nitrogen, phosphorus and organic carbon for optimum yield production of different cultivated crops. The physical and chemical properties of the soil are shown in Table 1.

Table 1 Some soil properties of the experimental site

Soil properties	Soil depth (cm)				
	0-23	23-65	65-80	80 – 105	105 - 125
FS (%)	40	23	22	21	24
CS (%)	37	33	43	42	40
Silt (%)	15	25	11	19	8
Clay (%)	8	19	24	18	28
Texture	LS	SL	SL	SL	SCL
H (paste)	7.5	7.3	8.1	7.8	7.5
Ece	0.35	0.37	0.42	1.1	3.2
ESP	3.0	3.0	4.0	5.0	8.0
CaCO3 (%)	0.8	2.6	10.4	0.2	27.5
O.C (%)	0.052	0.066	0.078	0.061	0.052
C/N ratio	4	4	5	5	5

L S = loamy sand, SL = sandy loam, SCL= sandy clay loam

Treatments and Experimental Design

The treatments were arranged in completely randomized a split-plot design with four replicates. The area of each sub- sub plot was 42 m^2 (6 × 7 m). The experimental units were two meters apart from each other. The main plots were assigned to canal sediments application with three rates (0, 20 and 40-ton ha^{-1}) and sub - plots were assigned to chicken manure with three rates (2, .2 and 4-ton ha^{-1}). The experimental procedures were the same for both seasons. Treatments and their abbreviations are illustrated in Table 2.

Table 2 Treatments Application and their Abbreviations.

Treatment	Operation	Abbreviation
Chicken Manure (MM)	0-ton ha^{-1}	CM_1
	2-ton ha^{-1}	CM_2
	4-ton ha^{-1}	CM_3
Canal Sediment (CS)	0-ton ha^{-1}	CS_1
	20-ton ha^{-1}	CS_2
	40-ton ha^{-1}	CS_3

Cultural practices

Wheat variety WadiElneel was used in this study. Sowing was done manually by digging on 20th of November for both seasons, with seed rate of 120 kg ha^{-1}, at 0.2 m inter-row spacing. Nitrogen and Phosphorus were added as recommended by Agricultural Research Corporation (Sudan). The crop was harvested on 21st of March in both seasons.

Collection of data

Plant samples were collected randomly from each experimental unit (sub- sub plot) and then growth and yield parameters were determined. A number of thousand seeds were picked randomly from each plot. The seeds were weighed and mean 1000-seeds weight (g) was obtained. Plants of the net area of one meter square (using steel frame of one meter square) were cut at the soil surface at harvest time in three different positions in each plot, tied in bundles and left to dry by air. After drying, they were weighed, then the mean biological yield (kg ha^{-1}) (dry matter plus grain) was determined. The biological yield samples were manually threshed and the grain yield as expressed in kg ha^{-1} was obtained. Also, straw yield (kg ha^{-1}) was determined as follows:

$Straw\ yield\ (kg\ ha^{-1}) =\ Biological\ yield\ (kg\ ha^{-1}) -\ Grain\ yield\ (kg\ ha^{-1})$.

Measurements of soil physical properties

The core sample method as described by Black, (1965) and Landon, (1984) was used to determine the soil dry bulk density (ρd). Soil core was obtained from 0-20 cm soil depth for each of experimental units at 80 days after sowing (DAS). The soil was oven dried at 105º C for 24 hours and weighed. The soil dry bulk density (ρd) for all soil samples was calculated by the following equation:

$$\rho d = Ms/Vt \quad \ldots\ldots\ldots 1$$

Where Ms is dry soil mass and Vt is the total soil volume.

Measurements of the soil moisture were done at 0 - 25 and 25 - 50 cm soil depths. Soil samples were taken by an auger. Readings were taken in the field, two days after irrigation at 80 DAS. The volumetric moisture content (Θ) was calculated by the following relationship:

$$\Theta = \rho d \times (Mm-Md)/Md \quad \ldots\ldots\ldots 2$$

Where Mm is the moist soil mass and Md is the oven dry soil mass.

Statistical analysis and interpretation of data

Statistical analysis was carried out using a computer software package (MSTAT). Significance of differences among the various characters under study was compared using Duncan's Multiple Range Test (DMRT). Results were presented in tabular forms.

3. RESULTES AND DISCUSSION

Climate

Generally, the climate of the study area is classified as arid which is characterized by high temperature in summer, lower in winter and low rainfall (Habiballa and Ali, 2010). Table 3 shows the average min. temperature, max. Temperature, mean temperature and relative humidity in both seasons (National Institute of Desert Studies Meteorological Station). It is cleared that the second season

was characterized by lower temperature in December and January and higher relative humidity percentage in all months compared to the first season, and the first season was characterized by higher temperature in February and March compared to the second season.

Table 3 Climatic parameters of experimental site in both seasons

Parameter	Max. Temp. (ºC)		Min. temp. (ºC)		Mean Temp. (ºC)		Relative humidity (%)	
	Season		Season		Season		Season	
Month	1st	2nd	1st	2nd	1st	2nd	1st	2nd
November	29.8	32.1	13.6	16.2	22.1	24.9	40	44
December	30.6	30.2	13.2	12.6	22.0	20.7	46	49
January	27.5	29.0	12.2	9.4	19.7	19.2	44	51
February	33.9	31.0	13.9	12.1	23.9	21.3	35	43
March	35.1	36.4	17.7	16.5	27.3	26.3	25	33

Source: (National Institute of Desert Studies Meteorological Station).

Bulk density and Moisture content

Results Table 4 shows the interaction effect of canal sediment and chicken manure on soil bulk density (gmCm-3) and soil moisture content (%) for both seasons. The analysis of variance revealed that amendments used had a significant ($P \leq 0.05$) effect in reducing bulk density and higher significant ($P \leq 0.001$) in increasing moisture content. From appeared results, it is cleared that addition of 40 ton per hectare of canal sediment with 4 ton per hectare of chicken manure reduced soil bulk density from 1.7 gm. cm-3 up to 1.43 gm. cm-3 to the control, this result is online with those of (Ahmed, 2010 and Awad Elkarim, 2008) whom stated that canal sediment and chicken manure were affected in reducing soil bulk density. It was evident from results that the interaction of canal sediment and chicken manure reached the highest value of moisture content (17.6%) compared to control (9.5%), this result was in conformity with that of (Ahmed et al., 2018; Agbede et al., 2008; Awad Elkarim, 2007) who found that moisture percentage increased significantly in response to organic manure application.

Yield and Yield Components

Figure 1 illustrates the effects of canal sediment and chicken manure on wheat plant height at maturity stage. There were a significant ($P \leq 0.05$) differences between the control and canal sediments recorded in both seasons; also, from results it was clear that heights wheat plant of 89 cm was obtained for the interaction of 40 ton per hectare and 4 ton per hectare of chicken manure treatment compare to control (58cm). Manure and canal sediment affected positively in wheat height, this result was in conformity with that of Ali, 2017 who stated that canal sediment affected significantly in increasing plant height of wheat, also Adeleye et al., 2010 mentioned that manure enhanced wheat yield and its components.

Thousand Seeds weight

Table 5 showed the weight of 1000 seeds (g) in both seasons as affected by the canal sediment and the chicken manure fertilizer. The data revealed that there were significant ($P \leq 0.05$) differences between the interaction of canal sediment and chicken manure compared to the control in season one, while there were highly significant ($P \leq 0.001$) differences between the control and the combination of treatments and control in the second season and this may be due to low temperature in the second season. Data indicated that the interactions of the canal sediment and chicken manure were contributed in enhanced wheat seeds weight and produce weight of 38.7 (g) compare to control of 30.3 (g). These results are in line with those of Ali, (2017) and Ahmed, (2010) who found that chicken manure positively increase wheat seeds weight.

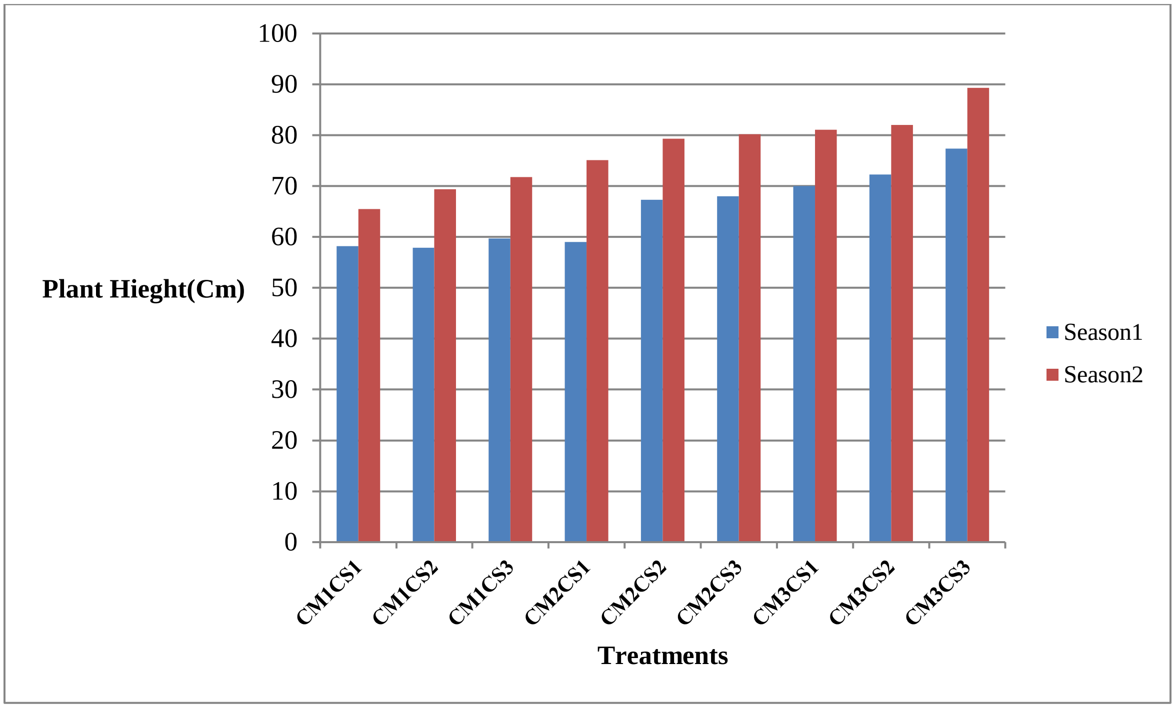

Figure 1 Illustrated wheat plant height at maturity stage versus treatments for both seasons.

Biological yield (Kg ha^{-1})

The results in Table 5 showed the means of biological yield as affected by canal sediment and chicken manure treatments in both seasons. Results appeared that there were highly significant ($P \leq 0.001$) differences among the interaction of canal sediment and chicken manure in both seasons. The highest biological yield of 9930 Kg ha^{-1} was obtained in the second season when using 40 Kg ha-1 of canal sediment with 4 t ha-1 of chicken manure and the lowest in the control 5353 Kg ha^{-1}. This result is online with that of Ahmed, (2010) who stated that chicken manure improved and produced high biological yield of wheat crop.

Straw yield (Kg ha^{-1})

The average straw yield in both seasons is shown in table 5. Results revealed that there were highly significant ($P \leq 0.001$) differences between the interaction of canal sediment and chicken manure in both seasons. The highest straw yield (6976 Kg ha-1) was obtained in the second season when combining 40 Kg ha-1 of canal sediment with 4 t ha-1 of chicken manure and the lowest in the control 4287 Kg ha-1. This result is in online with that of Agbede, (2008) who stated that chicken manure affected in increase yield and yield components.

Wheat grain yield (Kg ha^{-1})

Table 5 Shows the means of wheat grain yield Kg ha^{-1} in the both seasons. Results indicated that there were highly significant ($P \leq 0.001$) differences between the interaction of canal sediment and chicken manure in both seasons. The highest value of wheat grain yield reached (9930 Kg ha^{-1}) in the second season when adding 40 Kg ha^{-1} of canal sediment with 4 t ha^{-1} of chicken manure and the lowest value of 6123 Kg ha^{-1} was obtained by the control in the first season. The same result was recorded by Ali, (2017) who stated that canal sediment enhanced wheat yield, also this result is in agreement with that of Rasool et al., (2015), who concluded that manure increased wheat growth and yield significantly.

Harvest index (%)

Table 5 Shows the average harvest index in the two seasons. Results appeared that there a significant ($P \leq 0.05$) differences between the interaction of canal sediment and chicken manure in both seasons. The highest value of harvest index (40%) was obtained in the first season when adding 40 Kg ha^{-1} of canal sediment with 4 t ha^{-1} of chicken manure and the lowest in the control of 30.1%. The same result was recorded by Ali, (2017).

Table 4 Interaction effects of canal sediment and chicken manure fertilization on soil bulk density (gcm-3) and moisture content (%) in both seasons

Parameters	Bulk Density (gmCm^{-3})		Moisture Content (%)	
Treatments	1st Season	2nd Season	1st Season	2nd Season
CM_1CS_1	1.62	1.70	10.3	9.5
CM_1CS_2	1.54	1.62	11.2	11.8
CM_1CS_3	1.65	1.50	11.4	12.4
CM_2CS_1	1.56	1.67	12.5	12.9
CM_2CS_2	1.50	1.61	12.8	13.1
CM_2CS_3	1.64	1.52	13.1	14.2
CM_3CS_1	1.59	1.74	13.1	15.9
CM_3CS_2	1.53	1.52	13.6	16.6
CM_3CS_3	1.46	1.43	13.6	17.6
SE ±	0.48	0.49	4.06	4.97
Sig	*	*	**	**

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.
* and ** indicate significance at P ≤ 0.05 and 0.01, respectively.

Table 5 Interaction effects of canal sediment and chicken manure fertilization on wheat yield Parameters for both seasons

Parameters	1000-seeds weight (g)		Biological yield (Kg ha^{-1})		Grain yield (Kg ha^{-1})		Straw yield (Kg ha^{-1})		Harvest index (%)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
CM_1CS_1	30.3	32.3	1837	5353	6125	7591	4287	5238	30	31
CM_1CS_2	32.0	34.6	2473	5564	7730	8012	5257	5448	32	32
CM_1CS_3	32.0	35.0	2561	6112	7208	9431	4647	6319	36	33
CM_2CS_1	31.0	31.7	2280	5840	6717	8113	4437	5274	34	35
CM_2CS_2	32.0	34.7	2506	6017	6780	8878	4273	5862	37	34
CM_2CS_3	33.7	36.0	2519	6325	7205	8750	4687	5425	35	38
CM_3CS_1	33.3	34.7	2277	6848	7352	9189	5076	6341	31	31
CM_3CS_2	33.6	36.0	2576	6050	7872	9534	5296	6485	33	32
CM_3CS_3	35.3	38.7	3116	7954	8630	9930	5514	6976	37	40
SE ±	1.62	2.10	374.71	782.48	782.80	2887.1	472.2	628.4	2.7	3.1
Sig	*	**	**		**	**	**	**	*	*

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.
* and ** indicate significance at P ≤ 0.05 and 0.01, respectively.

4. CONCLUSION

It can be concluded that canal sediment is best solution of weakly developed profile and loose consistency sandy soil of high terrace site - Northern State of Sudan, manures especially that from chicken is a promise solution for poor and infertile soil of these area which is facing from deficit in micro and macro elements.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Funding
The study has not received any external funding.

Data and materials availability
All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Adeleye EO, Ayeni LS. Ojeniyi SO. Effect of poultry manure on soil physio-chemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on Alfisol in South Western Nigeria. Am J Sci 2010; 6(10):871-878.
2. Agbede TM, Ojeniyi SO, Adeyemo AJ. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in Southwest Nigeria. Am Eurasian J Sustain Agric 2008; 2(1):72-77.
3. Ageeb OA, Elahmadi AB, Solh MB, Saxena MC. Wheat Production and Improvement in the Sudan. Proceedings of the National Research Review Workshop 27- 30 August 1995, Wad Medani, Sudan. (Eds.) viii 1996; 262.
4. Ahmed IA, Ahmed MM, Hamad ME. Direct and Residual Effects of Green Manure on Some Soil Physical Properties of Desert Plain Soils and Wheat (Triticum aestivum L.) Yield in New Hamdab Scheme, Northern State, Sudan. Sudan J Des Res 2018; 10(1):1–16.
5. Ahmed IA. Effect of Tillage Methods, Green and Farmyard Manures on Wheat Yield and Properties of Desert Plain Soils, Northern State, Sudan. M.Sc. thesis, University of Gezira, National Institute of Desert Studies 2010.
6. Ali AM. Effects of Fertilization with Humate and Canal Sediment and Irrigation Intervals on Soil Properties and Wheat Performance in High Terrace Soils, Northern State, Sudan. Univesity of Gezira, Sudan, Phd thesis 2017; 64-66.
7. Almeu A, Hazem A. Government of Sudan and FAO/WFP Crop and Food Security Assessment Mission to the 15 Northern States of Sudan 2011. Available at: http://www. documents.wfp.org/stellent/groups/public/documents/ena/wfp231348.pdf
8. Awad Elkarim EE. Wheat Grain Yield on Mukabrab Soil Series as Affected by Disc Ploughing, Chiseling, Farm Yard Manure and Nitrogen. Phd Thesis, University of Gezira, Sudan 2007.
9. Black CA. Methods of soil analysis. Monograph No. 9, Part 1: Phyical and Mineralogical Properties, Am Soc Agron 1965.
10. Elhadi EA, Mubarak AR, Rezig FAM. Effects of organic amendments on sand dune fixation. Int J Recycl Org Waste Agricult 2016; 5:1-8. doi: 10.1007/s40093-015-0111-5
11. Habiballa AM, Ali AM. Classification of Climates Using Aridity Indices. Sudan J Des Res 2010; 12:62-75.
12. Land and Water Research Centre (LWRC). Detailed Soil Survey and Land Suitability Classification of Multaga Scheme. Agricultural Research Corporation, Land and Water Research Centre, Wad Medani, Sudan 1999.
13. Landon JR. Booker Tropical Soil Manual. A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman, Inc, New York, USA 1984.
14. Mubarak AA, Hassan AA, Ahmed IA, Eltilib AMA. A Note on the Impact of Dry Sewage Sludge and Hamdab Irrigation Canal Sediment on some Quality Attributes of an Aridisols, Northern State. Sudan J Des Res 2015; 7(1):132-141.
15. Mubarak AA, Hassn AA, Ahmed IA, Eltilib AMA. Use of Dry Sewage Sludge and Clay Based Ameliorant for Production of Wheat (*Triticum aestivum* L.) in a Desert Soil II: Effects on Yield and Nutrient Content. Sudan J Des Res 2014; 6(1):67-78.
16. Rasool GH, Wahla AJ, Nawaz M, Abdur Rehman M. Determination and Evaluation of the Effect of Different Doses of Humic Acid on the Growth and Yield of Wheat (*Triticum aestivum* L.). J Agric Vet Sci 2015; 8(2):5-7.